

RESILIENT NETWORKS  
POMS International Conference 2022 Budapest  
June 29-July 1, 2022



POMS



Book of Abstracts

## Keynote Presentations

# Integrated Data-driven Solutions in Decision-making Systems

Zuo-Jun (Max) Shen

*University of Hong Kong, Hong-Kong*

Big data provides new opportunities to tackle one of the main difficulties in decision-making systems – uncertain behavior following an unknown probability distribution. Standard data-driven approaches usually consist of two steps. The first step involves predicting or estimating the uncertainty behavior using data. Then the second step requires finding decisions that optimize an objective function that depends on the output of the first step. Instead of the classical two-step predict-then-optimize (PTO) procedure, this tutorial examines data-driven solutions that integrate these two steps. We first introduce the problem formulation as a contextual stochastic optimization. In this formulation, the objective function depends on the unknown uncertainty and the distribution of the uncertainty is associated with some contextual information. Massive data is often available to solve this problem, including historical observations of the uncertainty and contextual information. Therefore, machine learning tools have become an important technique to achieve integrated data-driven solutions. Yet, it is noteworthy that the goal of the integrated data-driven solution is very different from traditional predictive tasks for machine learning. Moreover, different integrated data-driven methods have shown applicability and effectiveness in many real-world decision-making situations, including inventory management, COVID-19 pandemic, and power system. To demonstrate the practicality and the real-world impact, we review current achievements of integrated methods in different real-world applications in operations management.

# Shifting of Gears in Hungarian Higher Education

Laura Sinóros-Szabó

*Head of Department at Ministry for Innovation and Technology, Hungary*

The Hungarian Government is committed to making higher education in Hungary successful, that is internationally competitive, student-oriented and equally accessible. According to the Hungarian model, the objectives can be achieved by preserving and maintaining the state's role and responsibility (funding), while providing a more flexible operational framework for the institutions, which is able to respond to economic needs faster. The structural change has affected a total of 21 universities involving two-thirds of the student population. The new maintenance logic has required a new financing system fitting both governmental and institutional goals. In this financing mechanism the state can shape the content focuses, priorities and activity portfolio of the institutions through the framework contract and the financing agreement. Performance expectations and the incentive system introduced will lead to higher quality guaranteeing advancement in international rankings, setting objectively measurable performance and inducing continuous innovation in higher education



# *Quo vadis* European Energy Markets? - Shocks and Lessons from the Last Decade

Péter Kaderják

*Ministry for Innovation and Technologies, Budapest, Hungary*

The speech will review major supply and demand shocks that hit the European natural gas and electricity markets since the last major Russian gas supply cut in 2009. It also evaluate the policy responses to those shocks at the EU and member state level to increase the resilience of network related energy industries in Europe. Conclusions on how to manage the current energy crisis in Europe are drawn.

## Special Sessions' Presentation



# Bring Your Publication Analysis to the Next Level with Intelligent Metrics

Eniko Toth Szasz

*ProQuest, part of Clarivate, Cambridge, UK*

Putting the citation count into context reveals the true impact of the publications. With the right intelligent and contextualized metrics you can build comparisons for true benchmarking. We will take a look at normalized metrics, percentiles, collaboration metrics and many more and showcase, how to use them for bibliometric analysis and get useful insight on institutional output and use multiple angles to understand and strategically position your organization within the international research ecosystem.

# Addressing Institutional Research Challenges with Metrics and Data

Anton Degtev

*Elsevier*

The paradox of today's research ecosystem is that it is highly competitive and collaborative at the same time. To succeed, a university needs information that supports strategic decision making so that its research can flourish, advance society and drive economic growth. On top of that, institutional achievements should be open and visible to potential partners, collaborators, ranking bodies and to the public. I will speak about the data, metrics, solutions and approaches to address these priorities and challenges for a University.



Oral Presentation

# Analyzing the Role of Validation in Online Communities

Roopendra Roopak, Somnath Chakrabarti

*IIM Kashipur, India*

*roopendra.fpm1716@iimkashipur.ac.in*

The role of the brand community has grown significantly in the past decade to drive online customer engagement (OCE). The present literature has explored the role of different antecedents in driving OCE through brand communities. The study aims to understand how the human need shapes OCE brand communities and the dynamics of influencers within the same context. To this end, we employed a mixed methodology, which involved interviewing relevant respondents. Findings indicated the unique antecedent of validation and its role in driving engagement. Further, it helped frame the research questions, specifically, we seek to answer: RQ1: What is need for validation, and how does it drive OCE? RQ2: What kind of influencers should be preferred and their contract type within the same context? Hayes' Process analyses were applied to test the higher-order moderated moderation relationship. The path analysis was conducted using Bayesian SEM. We found that validation has its root in social and status needs, where social need has a positive indirect effect on OCE while status need has a negative indirect effect. We tested the role of platform trust and commitment interacting with membership length with the community and found various relations with OCE. The study indicates that brands with customers having higher validation needs should consider traditional celebrities, while those having lower esteem needs should go for social media influencers who have become famous through social media. Further, firms should opt for contracts wherein influencers are asked not just to promote but to respond to a few users.

# Opinion Mining of Environment Friendly Policy on Twitter: Impact of Political Affiliation on User Generated Content

Kapil Kaushik, Nikunj Jain

*Indian Institute of Management Nagpur, Nagpur, India*

Individuals express their support or opinion about government policies on social media platforms such as Twitter. Public opinion expressed by citizens on the social media platforms is an important factor for support and acceptance of any new government policy. In this study, we explore the impact of political affiliation on the polarity, length, and assertiveness of content generated by social media users. This study investigates the political affiliation heterogeneity using the "*Social Identity Theory*," which analyzes political affiliations' influence on opinion of users about an environment friendly policy. A case study on an *Odd-even restrictive driving policy* implemented during November 4-11, 2019, in Delhi (India) is undertaken for exploring how users with different political affiliations expresses their opinion and views related to restrictive driving policy. First, public responses were downloaded from "*Tweets*" and analyzed to understand the opinion of people towards odd-even driving policy. The findings show that political affiliation influences opinion, sentiment, and other content characteristics (such as length, hashtags, and number of users mentioned) expressed by users in the tweets. This study may help policy-makers and regulators design measures and interventions that support broader public support towards environment friendly policies through political affiliation.

**Keywords:** environmental policy, political affiliation, sentiment analysis, social media, opinion mining, social identity theory

# Characterizing and Comparing COVID-19 Misinformation Across Languages, Countries and Platforms

Golshan Madraki

*Assistant Professor of David. D. Reh School of Business, Clarkson University, USA  
gmadraki@clarkson.edu*

Misinformation/disinformation about COVID-19 has been rampant on social media around the world. In this study, we investigate COVID-19 misinformation/ disinformation on social media in multiple languages/countries: Chinese (Mandarin)/China, English/USA, and Farsi (Persian)/Iran; and on multiple platforms such as Twitter, Facebook, Instagram, WhatsApp, Weibo, WeChat and TikTok. Misinformation, especially about a global pandemic, is a global problem yet it is common for studies of COVID-19 misinformation on social media to focus on a single language, like English, a single country, like the USA, or a single platform, like Twitter. We utilized opportunistic sampling to compile 200 specific items of viral and yet debunked misinformation across these languages, countries and platforms emerged between January 1 and August 31. We then categorized this collection based both on the topics of the misinformation and the underlying roots of that misinformation. Our multi-cultural and multi-linguistic team observed that the nature of COVID-19 misinformation on social media varied in substantial ways across different languages/countries depending on the cultures, beliefs/religions, popularity of social media, types of platforms, freedom of speech and the power of people versus governments. We observe that politics is at the root of most of the collected misinformation across all three languages in this dataset. We further observe the different impact of government restrictions on platforms and platform restrictions on content in China, Iran, and the USA and their impact on a key question of our age: how do we control misinformation without silencing the voices we need to hold governments accountable?

**Keywords:** COVID-19, Misinformation/Disinformation, Social Media, Different, Languages

# Stock Market Prediction by Social Media amid the Pandemic: The Growing Digital Divide

Yu-Chao Cheng, Guan Chong

*Singapore University of Social Sciences, Singapore*

The hazards presented by the pandemic have kicked in since the global spread of COVID-19 in 2019, and stock markets throughout the world have fallen. Investors' fears about the outbreak circulated swiftly over social media, but they soon vanished. Correspondingly, the decline was followed by a brief bear market that quickly bottomed out and rebounded. Meanwhile, since the digitally advanced businesses look to be holding up in this Coronavirus-affected market, technology companies have attracted a lot of attention. The purpose of this study is to examine market sentiment on social media in order to forecast stock market performance before, during, and after the March 2020 stock market crash. Furthermore, using the OECD taxonomy of sectors by digital intensity, we identified market sectors that outperformed others in stock markets when market sentiment was influenced by the pandemic's unfolding. A mix of hierarchical clustering and shape-based distance measure was used to assess the daily stock performance of a selected sample of 1610 enterprises. Using augmented vector auto-regression, we found that market perceptions of the pandemic have had a major influence on stock price variations. More intriguingly, the amount of digital intensity is a determinant of stock performance across sectors, with the most digitally advanced industries displaying resilience to negative market attitudes on the pandemic.

# How to Decide on KOLs and Video Production in Livestreaming and Short Video Promotion

Wang Yue

*Singapore University of Social Sciences, Singapore*

Livestreaming and short videos have become one of the most important channels to lead traffic, acquire customers and drive sales. Companies nowadays utilise influencer marketing in social network, and rely on KOLs to generate livestreaming and short videos to help promote their products and services on various platforms. One important question to ask is what are the key characteristics of KOLs to consider and how to construct the short videos to optimize the effectiveness. Meituan is the leading food delivery platforms in China. It has the strong need to expand the market and increase revenue. Meituan deploys KOLs to put short videos on Kuaishou, a leading short video platforms in China to boost its installation rate and purchases. This paper combines data from Meituan advertising spending, conversions from short videos and the characteristics of KOLs on Kuaishou who help with Meituan's promotion to understand the relationship between KOLs' characteristics and the short video ads effectiveness. We find that in order to increase the short video ads' ROI and increase the conversion rate, we could have the following selection criteria: KOLs with more female fans, with fans from third, fourth and fifth-tier cities, positive fan base growth in the past 90 days, and the concentration is on food and entertainment. In-depth video analysis is done to further examine how the video characteristics, including sound, facial expression, close-up or long shots and number of shots, etc., could affect the effectiveness. Managerial suggestion about KOL selection and video production could be provided.

**Keywords:** short videos, Meituan, Kuaishou, influencer marketing, KOL, characteristics, effectiveness

# The Cultural Impact on COVID 19 Crisis in the MENA Area

Xiangrong Liu, Wanchunzi Yu

*Bridgewater State University, Bridgewater, USA*

The CoViD-19 pandemic created the greatest chaos in public health, politics, and citizen's normal life worldwide. Like all the other developing countries world widely, the Middle East and North Africa (MENA) countries are significantly impacted. Cultural factors are playing important roles in the policy decision making process regarding the measures and the results and CoViD-19. This study used the CoViD-19 data in nineteen MENA countries sourced by the World Bank. Using the random effect models, the work investigates how the CoViD-19 in MENA countries are affected by the cultural factors: power distance, individualism, masculinity, uncertainty avoidance, long-time orientation, and indulgence, in addition to the other factors including GPD, life expectancy, human development index.

# The Impact of Service Failures on Firm Profitability: Integrating Machine Learning and Statistical Modeling

Davood Golmohammadi<sup>1</sup>, Mahour Mellat Parast<sup>2</sup>, Nada Sanders<sup>3</sup>

*1 University of Massachusetts Boston, USA; davood.golmohammadi@umb.edu;*

*2 Arizona State University, USA; Mahour.Parast@asu.edu*

*3 Northeastern University, Boston, MA, USA; n.sanders@neu.edu*

The generally accepted view among managers and researchers is of a direct linear relationship between service quality and profitability. Supported by the strategy-structure-paradigm (SSP), we argue that the relationship between service quality and organizational performance is impacted by strategy. Using historical data from the U.S. airline industry, we study the impact of various service failures on financial performance between airlines pursuing different strategies (low cost vs. legacy). Using a novel methodological approach that includes neural network modeling and statistical data analysis, we find that the impact of service failures on profitability is not linear but differs between the two groups across all measures (flight delays, involuntary denied boarding, and mishandled baggage). Most interestingly, it is the *pattern* of the relationship that is distinctly different. These findings reveal the nuanced impact that service failure has on profitability. Although customer complaints are found to have the most significant impact, the pattern of impact is not linear and is distinctly different between the two groups. These findings challenge the conventional belief that reducing customer complaints goes hand in hand with improving financial performance. The results provide significant managerial implications and contribute to the existing body of knowledge on service quality and operations strategy.

# Can D2C Save Disrupted Supply Chains? Blockchain B2B Comes to the Rescue

Jinwook Lee<sup>1</sup>, Lanqing Du<sup>1</sup>, Sejong Yoon<sup>2</sup>, Paul Choi<sup>3</sup>

*1 Drexel University, Philadelphia, USA; jl3539@drexel.edu*

*2 The College of New Jersey*

*3 Ewha Womans University*

What once seemed long-lasting, the business-to-business-to-consumer (B2B2C) model has gradually shifted to the direct-to-consumer (D2C) alternative. This transition has been accelerated due to the COVID-19 pandemic, which has negatively affected the global supply chain with a wide range of obstacles producing escalated uncertainty in production, labor markets, logistics, financial sectors, etc. These trends motivate us to investigate new business models through innovative operations. This research studies how centralized D2C business models can enhance by decentralized business-to-business (B2B) channels to mitigate supply chain disruptions. The strategic guidance and managerial benefits of our new model are demonstrated through network representation, simulation, and optimization models. To address the product, financial, and information flows of our architecture, resilience under delivery disruptions, cryptocurrency payment fintech for NFTs, participants' rewards and fees balancing, and peer-to-peer information network are discussed. Overall, the numerical stress tests for our business model – under supply chain disruptions – show that (1) the customers still receive parcels on-time or earlier; (2) the local B2B partner retailers gain sales from second deliveries; and (3) the manufacturers save related shipping costs, reduce potential customer loss and refund issues, and shorten communication time between customers and agents.

# Business Continuity and Strategic Responses – Role of the Corporate Immune System in the Crises

Sławomir Zapłata<sup>1</sup>, György Drótos<sup>2</sup>, Róbert Marciniak<sup>2</sup>

*1 Poznan University of Economics and Business, Poznan, Poland*

*2 Corvinus University of Budapest, Budapest, Hungary*

Organizational resilience (OR) is an inherent characteristic of every organization, a set of elements that create the ability to run a business in a changing environment. In order to strengthen OR, any organization can concentrate its activities in the area of business continuity management (BCM). The systemic approach to BCM aims to minimize losses and maximize the chances of survival during a crisis situation. Organizations undertake various actions with regard to both of these concepts. Learning about Covid Crisis (CC) or any former crisis by organizations has a significant impact on future improvement. These issues influenced the idea of research and the purpose of the article expressed in the question – How do organizations cope with a crisis and how do they use past experiences for future improvement of operations? Based on the literature review and using the analogy of the human immune system, authors have improved a new, conceptual model of how the corporate immune system functions in crisis situations. The theoretical model will test by an empirical case study research to analyse the role of OR and BCM to build a crisis-proof organization, which has practical implications.

**Keywords:** organizational resilience, business continuity management, corporate immune system, crisis, crisis management

**JEL Classification:** H12, L2, M2

# Crises / Disaster Management & Covid-19 Pandemic

Rashda Abbas

*The University of Punjab, Lahore, Pakistan*

A crisis is the ultimate test we can endure. Covid-19, the 'mother of crises' caused a series of unthinkable financial, social, political, medical and emotional turmoil. Especially, the global business scenario dramatically changed. Covid-19 completely shook the business leaders off. All leadership playbooks became irrelevant. Five-year strategic business plans made no sense anymore.

Based on our study, with over 100 global organizations, I am revealing a five-step solution to deal with this crisis. I call it P.R.I.C.E. Framework:

1. Promise: What future you commit to co-create?
2. Risk: What discomforts you are willing to embrace?
3. Innovate: How to re-model the organization to cope with the crisis?
4. Change: How to thrive in the new normal?
5. Empower: How to instil resilience and ownership at all levels?

Our study proved that when a leader commits to deliver certain results and takes risks to pursue those goals, innovation can inspire new solutions for the current pain-points. Change in behavior is an essential component to fuel empowerment to deliver the desired outcomes.

The P.R.I.C.E. framework focuses on modifiable behaviors that can unleash a plethora of solutions to complex problems faced by the leaders of today.

In addition to it, my article provides the answers to the following questions:

1. How can organizations survive today and thrive tomorrow?
2. How to adapt to the re-set button while building hope and protecting optimism in the organization?

# Expansion Strategies of Sharing Platforms Offering Either B2C or C2C Sharing Services

Tania Saha, Sumanta Basu, Balram Avittathur

*Indian Institute of Management Calcutta, Joka, Kolkata, India;  
tantias16@iimcal.ac.in*

Sharing platforms (SPs) enable renters to get temporary access to products in return for a fee. Consumer-to-consumer SPs (C2C-SPs), like Tulerie, facilitate lenders to share their idle products (lender-owned products or LP) with the renters. Business-to-consumer SPs (B2C-SPs), like, Endless Wardrobe provide their own products (platform-owned products or PP) for rental. While some C2C-SPs provide only LPs, other C2C-SPs, like Hurr Collective have expanded into B2C sharing service by offering PP and operating as a hybrid SP (HYB-SP). However, hardly one can find a B2C-SP that has expanded into a C2C sharing service by allowing collaboration among consumers. Furthermore, renters may also face performance risks from LP and PP, where the relative acceptance of LP can be higher or lower than PP along with psychological risks from “stranger sharing” in C2C transactions. To alleviate the renter’s psychological risk, C2C-SPs invest in improving service quality in the C2C market. So, we examine how these factors influence the SP’s expansion strategies. The analysis shows that a higher acceptance of PP than LP would induce the C2C-SP to always extend into offering PP which would be associated with a reduction in the C2C service quality. However, if this acceptance is higher towards LP than PP, then the C2C-SP would transition to HYB-SP when it incurs a higher expenditure for C2C service quality improvement. This higher expenditure for service quality improvement and the inability to charge a high commission fee to the lender is what might be restricting the B2C-SP in transitioning to HYB-SP.

# Efficient Multimodal Transportation through Drones and City Buses to Serve the B2C e-Commerce Last-Mile Deliveries

Si Liu<sup>1</sup>, Zhecheng Xie<sup>2</sup>

*1 DeGroote School of Business, McMaster University, Canada*

*2 Pittsburgh Institute, Sichuan University, China*

The exponential growth of e-commerce has greatly increased the number of parcels to be delivered and put pressure on the supply chain, especially the last mile deliveries. To tackle these challenges, we utilize an innovative concept to apply multimodal transportation of drones and city buses to serve the B2C e-commerce last-mile deliveries. The B2C e-commerce parcels are inserted into buses at bus terminals, and the drones will deliver the parcels between the parcels' final destination and bus stops that are closest to the final destination during the bus berthing time. This paper optimizes the size of the drone fleet for the drone-bus system when all delivery demands are satisfied. We provide an integer programming model to formulate the problem and exactly suited solution procedures. We also discuss the possible benefits and challenges in further implementing this concept.

# Smart Manufacturing Readiness Model – Conceptualizing ‘Level 0’ for SMEs

Andrea Gelei, Katalin Ternai, Elizabeth Lengyel

*Corvinus University of Budapest, Hungary*

Technology-driven business and operational excellence is a widely discussed research area. Specifically, Smart manufacturing (or Industry 4.0) solutions seem to be promising. Despite its potentials, manufacturing firms, small and medium-sized enterprises (SMEs) in particular, seem to be lagging in implementation. Extant research emphasizes that SMEs severely lack basic capabilities necessary to successfully implement such solutions. Several smart manufacturing readiness models have been developed with the objective to capture these prerequisites, called “level 0”. Elements of this “level 0” are manifold themselves and not easy to develop, however. Additionally, the shift from this base level to “level 1” might be even more challenging than the shift between any other levels of such models. Thus, several papers have called for additional research in this area.

The objective of our research is to fill this research gap and develop a Smart manufacturing readiness model extensively discussing the very basic capabilities that an SME needs before launching a Smart manufacturing initiative. Using Design science research methodology, we have developed and would like to present and discuss a Smart manufacturing readiness framework elaborating this “level 0” in more detail. It is based on a literature review and expert interviews, and discusses three main building blocks and the relationship among them, namely: (1) process, (2) digitalization, and (3) cyber security capabilities.

# Analyzing Customer Engagement in Response to Pricing Strategies for Over-the-top (OTT) platform

Roopendra Roopak, Asit Tripathy

*IIM Kashipur, India*

OTT industry is facing intense competition from big players like Apple, Disney, Amazon and Hulu. Moreover, the influx of big players is a severe challenge for present industry leaders like Netflix. They believe that they are experiencing stagnation in customer growth rate or erosion in some cases because of other players entering the industry. When competition is such intense, firms need to keep their customers more engaged to maximize overall firm profit. However, the effort to engage customers is a costly activity. Thus, deciding the optimal level of engagement effort is critical for the firm. Given the aforementioned scenario, we attempt to develop analytical models to understand the role of the engaged customer in response to the pricing strategies on OTT platforms. To address the gap in the literature, we broadly like to answer the following research questions: RQ1: How do various pricing strategies (pricing plans) impact a firm's revenue when the strategic customers are considered, and heterogeneity among customers exists? RQ2: How do various pricing plans and different levels of engagement affect consumer surplus and social welfare at large? Past work in information goods has enabled us to develop an effective way to represent the OTT parameters into an analytical model. The above research questions have been answered by developing a stylized gametheoretical model. The analysis of the obtained closed-form solutions has enabled us to address the problems in an interesting way.

# Impact of Additive Manufacturing on the Role of Supply Chain Management and Logistics Service Providers in Supply Chains

Marta Malik, Anna Aminoff

*Hanken School of Economics, Helsinki, Finland*

Additive manufacturing is expected to drive resilience of future supply chains. During the COVID-19 pandemic, implementation of additive manufacturing helped medical supply chains meet the spike in demand for medical equipment. Widespread introduction of additive manufacturing to spare parts supply chains is seen as an appealing way of building network resilience. However, it certainly triggers changes in the supply chain configuration affecting the way logistics service providers and supply chain function of an original equipment manufacturer shall operate. Hence, the study investigates how the role of supply chain management function of an original equipment manufacturer changes and what role would a logistics service provider play within the spare parts supply chain, once additive manufacturing is introduced. To get the answers, we conduct interviews with original equipment manufacturers and logistics service providers in Finland. We apply inductive approach to interview design. The findings reveal inevitable changes required in supply chain operations and capabilities that introduction of additive manufacturing brings in for logistics service providers and original equipment manufacturers. The study concludes with theoretical and practical implications.

# Change Management in Supply Chain: Towards a Definition of Supply Chain Change and Supply Chain Change Management

Hebatollah M. Morsy, Ehab Yaseen, Lamia Shihata

*German University in Cairo, Cairo, Egypt*

A series of disrupting events has been hitting the world lately, in the form of political instabilities and disputes, spread of contagious diseases and economic disruptions as well, resulting in severe fluctuations in the business environments. Those disruptions affected the supply chains by causing many changes in its configuration and design, to be able to cope with it and deal with its consequences. This raised the importance of understanding change in supply chain. Consequently, a flashback on the previous literature was done to explain the phenomenon of change in the context of supply chain. Although some researchers explored change in supply chains but they did not clarify a definition for the concepts of supply chain change, and supply chain change management. Therefore, the paper aims at providing a clear definition to supply chain change and supply chain change management in the light of organizational change management literature, supply chain management literature, and complex adaptive system theory. The Straussian grounded theory was adopted as the research method, where data was collected using semi-structured interviews with supply chain managers and practitioners. Accordingly, after conducting six iterations of data collection, coding, and analysis, the definitions of supply chain change, and supply chain change management were identified.

# Vehicle Repositioning Under Uncertainty

Qinshen Tang<sup>1</sup>, Minglong Zhou<sup>2</sup>, Yu Zhang<sup>3</sup>

*1 NTU, Singapore, Singapore*

*2 National University of Singapore, Singapore*

*3 Southwestern University of Finance and Economics, Singapore*

We consider a general multi-period repositioning problem in vehicle-sharing networks such as bicycle-sharing systems and free-float car-sharing systems. This problem is subject to uncertainties along multiple dimensions—including demand, travel time, and repositioning duration—and faces several operational constraints such as the service level and cost budget. We propose a risk mitigation model to tackle these uncertainties. This paper is the first, as far as we know, to incorporate various time-dependent uncertainties. We then reformulate the model and efficiently obtain solutions by solving a sequence of mixed-integer linear optimization problems. Extensive simulation studies demonstrate that our model yields remarkable performance in various settings and is computationally scalable. We find that our model, when compared to such benchmarks as "fluid-based optimization", achieves the highest average service level for a given repositioning cost budget.

# *Need for Speed, but How Much Does It Cost?*

## Unpacking the Fee-Speed Relationship in Bitcoin Transactions

Guangzhi Shang

*Florida State University, Tallahassee, USA*

Recent cryptocurrency studies have concentrated on price prediction (Bouri et al., 2019b; Li and Wang, 2017), price manipulation (Fry, 2018; Gandal et al., 2018), market participant behavior (Bouri et al., 2019a; Roşu and Saleh, 2021), and market design (Huberman et al., 2019). However, so far, less attention has been given to studying operational fundamentals such as the transaction fee mechanism that regulates the confirmation times in most cryptocurrencies (e.g., Bitcoin). From a modeling standpoint, the confirmation process in a cryptocurrency blockchain can be viewed as a priority queueing system with priorities determined by transaction fees (Kawase and Kasahara, 2020). Fees are payments made by the users of a cryptocurrency in order to facilitate transaction processing (Lu et al., 2021). Users are permitted to offer any fee amount (i.e., flexible fees) to compete for the computing resources provided by miners – a special type of users who provide the computing power to validate a transaction. All else equal, offering higher fees is expected to increase the speed that a transaction will be processed because economically rational miners choose to validate the transactions with higher fees first.

With the broader adoption of cryptocurrency technology and the increasing volume of transactions arriving to cryptocurrency networks, the amount of fees users pay continue to grow. In 2020, the average fee in the Bitcoin system<sup>1</sup> has been 2.87 USD per transaction and the total amount of transaction fees paid to miners was over 326 million USD<sup>2</sup>. Besides its increasing magnitude, the volatility of transaction fees has also been dramatic. For instance, as of January 2021, the average fee per transaction has jumped to 11.35 USD. This spike was fueled by the surge in transaction volume occurring on Bitcoin exchange sites leading to the congestion in the network (Deka, 2021). It is important to note that such an increase in fees did not necessarily translate to faster processing times as during the same period, the average time for a transaction to be confirmed in the system also increased by 58% – from 74.6 minutes to 117.9 minutes<sup>3</sup>. This seemingly counter-intuitive outcome is caused by a design feature that limits the maximum throughput on the Bitcoin network to 7 transactions per second, regardless of the

---

<sup>1</sup> Bitcoin is the original and most popular cryptocurrency system in use today with over 60% of the cryptocurrency market share in 2020.

<sup>2</sup> <https://www.blockchain.com/charts>

<sup>3</sup> <https://www.blockchain.com/charts/avg-confirmation-time>

amount of fees offered (Croman et al., 2016). (See Section 2.2 for details about the throughput limit).

The aforementioned statistics allude to two facts. First, the average fee paid per transaction is correlated with the adoption of this technology and will continue to increase as long as the throughput limit embedded in system protocols stays in effect. Second, there exists an inherent uncertainty in the appraisal of fees as the same amount of fee might lead to vastly different service outcomes (in terms of transaction confirmation speed) at two different times. Basu et al. (2019) argue that the day-to-day volatility in transaction fees makes it very difficult to determine the proper fee amount in accordance with the confirmation time desired by users and hence leads to poor service quality. The goal of this paper is to address this concern by asking: *what is the relationship between transaction fee and transaction confirmation speed in the Bitcoin cryptocurrency system?* In particular, we focus on the fee's nuanced impact under different service levels and varying degrees of network congestion. To the best of our knowledge, there is no existing empirical research that systematically investigated the impact of fee on speed at the transaction-level<sup>1</sup>.

The contributions of this paper are threefold. First, we stylize the intricate Bitcoin transaction system with a clear process description using an OM perspective. Despite Bitcoin's first introduction by Nakamoto (2008) over a decade ago and hyped media coverage since then (Philippas et al., 2019), fundamental questions such as how the Bitcoin transaction confirmation process works and what the mechanisms underlying fee's impact on speed are remain unanswered. The institutional details presented in this paper represent a crucial first step in unpacking the underpinnings of the transaction fee mechanism and bringing this context into the OM community. Second, to delineate the fee-speed relationship in detail, we develop a theoretical framework that traces the journey of a transaction from being submitted to the service queue (i.e., pending transactions referred to as the memory pool) to being included in a future block. Our framework shows that confirmation time is jointly determined by the inter-arrival time between blocks and the probability of being confirmed in future blocks, and the causal effect of fee on speed is transmitted via the latter. Specifically, by considering all pending and projected transactions that are potentially competing for a spot in a future block, we reveal that the impact of fee on speed propagates through two priority pools (visible and invisible) in the queue. In other words, it is not purely the nominal fee but also the priority ranking of a transaction in the queue that collectively determine the confirmation times. Furthermore, we find that increasing fees have a much larger impact on the tail of the confirmation time distribution than on the mean – a phenomenon that we refer to as the tail shrinkage effect. This is insightful for Bitcoin users who care more about a certain service level target than the expected confirmation time. Third, to demonstrate how our results can be used to improve fee recommendation, we develop a computationally

---

<sup>1</sup> In our literature survey, the only similar study that we identified is by Easley et al. (2019), who studied the impact of speed on fee using the aggregate daily-level data.



efficient three-step procedure that calculates the distribution of confirmation time under a wide range of fee inputs. For a user with a desired transaction service level such as *"confirmed in the next 60 minutes with a 90% likelihood"*, our computational procedure recommends a best fee to achieve this goal.

# Scheduling Vehicles with Heterogeneous Service Rates: Optimizing Post-Harvest Preprocessing Operations for Fruits and Vegetables in Short Food Supply Chains

Lin Na<sup>1</sup>, Akkerman Renzo<sup>1</sup>, Kanellopoulos Argyris<sup>1</sup>, Xuping Wang<sup>2</sup>,  
Junhu Ruan<sup>3</sup>

*1 Wageningen University and Research, Wageningen, The Netherland*

*2 Dalian University of Technology, China*

*3 Northwest A&F University, China*

This study focuses on the post-harvest preprocessing of fruits and vegetables, aiming to provide an effective way to conduct preprocessing operations in short food supply chains. We consider both a heterogeneous fleet of mobile preprocessing units and the possibility to pick up products for centralized preprocessing. The resulting problem is a variant of the classic vehicle routing problem with time windows, extended to account for heterogeneous service rates among vehicles, as well as the distinction between mobile processing and centralized processing. These characteristics are important to consider in the development of more sustainable food supply chains, but lead to a challenging scheduling problem. We define the problem as the multi-type preprocessing service resources scheduling problem (MTPSRSP) and formulate it using a mixed-integer linear programming model. Due to the complexity of the model, we also propose a customized adaptive large neighborhood search (ALNS) metaheuristic. We demonstrate the effectiveness of the ALNS algorithm based on small-scale MTPSRSP instances and three sets of VRP benchmark instances. Results are compared with results of an exact algorithm and best-known solutions in the existing literature. Furthermore, we study the example of precooling, a commonly used preprocessing operation, to illustrate the effectiveness of our approach in a relevant practical context.

# Digitalization of Manufacturing and the Role of Human Resources: A Case-based Investigation

Ottó Csiki<sup>1</sup>, Levente Szász<sup>1</sup>, Béla-Gergely Rácz<sup>1</sup>, Krisztina Demeter<sup>2</sup>,  
Dávid Losonci<sup>2</sup>

*1 Babeş-Bolyai University, Cluj-Napoca, Romania*

*2 Corvinus University of Budapest, Budapest, Hungary*

**Purpose:** The ongoing digital transformation of the manufacturing industry, identified commonly under the umbrella term of Industry 4.0 (I4.0) is not just a purely technological process: it has widespread interactions with several organizational aspects of the adopting firm, including its human resource base. Nevertheless, the human resource implications of implementing Industry 4.0 technologies have received far less attention in literature. Therefore, the purpose of this paper is to extend previous research by investigating the role of human resources related to digital manufacturing technology adoption projects during (a) different adoption stages (pre-implementation, implementation and post-implementation phase) and (b) in relation with different organizational levels (shop-floor, development experts and managers).

**Design/Methodology/Approach:** Given the scarcity of results in the literature, this paper adopts an exploratory, multiple case study approach. Data collection is primarily carried out through semistructured interviews with managers, complemented with site visits and secondary data collection. Altogether, 5 manufacturing plants are investigated in two different countries, all of them being subsidiaries of automotive multinational companies.

**Findings:** We find that training and development of human resources is crucial across all implementation stages and organizational levels, however, with different emphases. Observed replacement effects are, so far, rare.

**Theoretical and practical implications:** Our research intends to go beyond the narrow focus of existing human-related studies in the I4.0 literature. From a practical perspective, our results aim to provide a tool for managers responsible for digitalization to identify most important activities, skills and competencies along the implementation journey to arrive at a successful technology adoption.

**Keywords:** digital manufacturing technologies, Industry 4.0, human resources

# How Community Group-buying Shapes Chinese Market During and Post Covid-19

Wang Yue

*Singapore University of Social Sciences, Singapore, Singapore*

Community group-buying has seen a rapid growth since the breakout of Covid-19 in China, and the growth has been continuing. Many giants of internet companies have entered into the competition, like Meituan, Pinduoduo, Didi, etc. As predicted, the market size will go up to USD 1.8 trillion by 2025. Community group-buying is an innovative online-offline business model which lets community leader collect orders and provide last-mile services in bulk, so that the community e-retailer could save on the operating expenses and delivery cost. In this paper, we are interested to explore the development of community group-buying in China since 2020, and how consumers' behaviour changed during the past 2 years. As Meituanyouxuan has now covered 20 provinces in China, we use the data from this platform to compare the difference in terms of product category, product selection, price, and customer base across the different markets in order to provide a holistic view about the marketing and operation.

**Keywords:** Community group-buying, Meituanyouxuan, consumer behaviour, marketing, operation

# Resilience Management of EV (Electric Vehicle) Supply Chain Network – An FMECA approach

Madampatty K. Loganathan<sup>1</sup>, Gabriel Anandarajah<sup>2</sup>,  
Antonio Zuorro<sup>3</sup>, Angappa Gunasekaran<sup>4</sup>

*1 The Assam Kaziranga University, Jorhat, india*

*2 UCL Energy Institute, University College London, London, United Kingdom*

*3 Sapienza - University of Rome, Italy*

*4 Penn State Harrisburg University of Rome, Italy*

Electrified mobility has created remarkable disruptions in the automotive business and is already on the way to mainstream adoption. The supply chain of EV technology pose real challenges for the OEMs in terms of development of EV platform, production of high capacity batteries, and evolution of new supplier base to ensure uninterrupted supplies of components and raw materials. Though the auto industries are developing new strategies to address the issues raising from EV production and supplies, yet it is apparent to notice that EV supply chain network face potential threats and failures that make the supply chain weak. This can, however, be mitigated to make the network resilient by employing appropriate risk analysis techniques. This paper suggests a method based on Failure Mode, Effects, and Criticality Analysis (FMECA) to identify the weak areas in EV supply chain network and their potential effects on the whole system. An exhaustive study has been conducted to collect the data of potential threats and supply chain failures in EV production and used as inputs for developing FMECA. This analysis will make it easier to determine which area can be adjusted and what action can be taken in order to enhance the resilience of the supply chain network. The developed tool can be further integrated into existing supply chain analytic of EV production system as a part of resilience management module.

# Linking Competitive Priorities to Smart Manufacturing Adoption and Performance

Francesco Arcidiacono<sup>1</sup>, Alessandro Ancarani<sup>1</sup>, Carmela Di Mauro<sup>1</sup>,  
Florian Schupp<sup>2</sup>

*1 University of Catania – DIEEI, Italy; francesco.arcidiacono@phd.unict.it*

*2 Jacobs University Bremen, Germany*

Smart Manufacturing (SM) lies at the core of Industry 4.0. While OM research has placed much emphasis on the technological antecedents of SM and the study of organizational factors is making its way in the SM research agenda, there is still of lack of understanding of how SM is informed by firms' competitive priorities. This study develops and empirically tests a model linking firms' competitive priorities to SM-enabled operational capabilities, using stages of adoption and organizational factors supporting SM as mediators. In turn, operational capabilities are envisaged to result in improvements in operational performance, along the four dimensions of cost, quality, delivery, flexibility. Survey data from 234 automotive suppliers are used to test a structural equation model. Findings suggest that firms approach SM driven by a simultaneous emphasis on multiple competitive priorities and that the creation of an organizational environment supportive of the digital transformation paves the way for actual adoption of SM technologies. In turn, SM-enabled operational capabilities ensure simultaneous improvements along all four dimensions of firms' operational performance, thus supporting firms in cumulatively building manufacturing capabilities. This study responds to ongoing calls in OM literature for research on antecedents of SM adoption and on how the digital transformation can drive performance benefits. Findings also provide guidance to manufacturing executives who are engaged in the SM transformation, by shedding light on the strategies of firms that engage in SM and by illuminating how technological and organizational factors complement each other and contribute to the performance benefits of SM.

**Keywords:** Smart Manufacturing, Manufacturing Strategy, Survey

# Blockchain Technology in the Supply Chain: Learning from Emerging Ecosystems and Industry Consortia

Wafaa A.H. Ahmed and Bart L. MacCarthy

*Nottingham University Business School, Nottingham, United Kingdom  
Wafaa.Ahmed@nottingham.ac.uk, Bart.MacCarthy@nottingham.ac.uk*

Blockchain is a potentially disruptive technology that supports immutability, transparency, and traceability for digital transactions. Blockchain shows promise for tackling several challenges in managing contemporary supply chains. Blockchain technology requires collaboration, which has resulted in the formation of many consortia to advance its adoption. Blockchain consortia are embryonic digital business ecosystems (DBE). We discuss the role of these consortia in addressing key blockchain challenges in business and supply chain applications. Dominant considerations central to a consortium's formation and sustainability are highlighted, including its governance, technical focus, and participation issues. For seven prominent blockchain consortia that encompass supply chain applications, we analyze the type of partnership, scope of activities, objectives and business model. Based on the study, five propositions are presented regarding the nature of blockchain consortia, the drivers for their formation, their collaboration requirements, the impact on relationships, and the influence of industry characteristics on a blockchain consortium's focus and characteristics.

**Keywords:** Blockchain Consortia, ecosystems, supply chain, digital business

# Staffing Service Systems with Cyclic Arrivals and State-Dependent Service Rates

Mohammad Delasay, Zhila Dehdari Ebrahimi

*Stony Brook University, Stony Brook, USA*

The “Stationary independent period-by-period” (SIPP) approach and its variants use stationary queueing models to set staffing requirements for systems with non-stationary arrivals. SIPP is commonly used for systems with fixed service rates. However, service rates in many real-world resource-intensive systems, such as emergency medical services, are state-dependent. We investigate how ignoring the statedependency of the service rates while using SIPP for staffing systems with non-stationary arrivals could result in inferior system performance. Specifically, we show that neglecting state-dependent service rates in some parameter settings could lead to staffing levels that miss the quality of service targets drastically during some periods of the day. We investigate when (with respect to the system parameters) it is more critical to accurately incorporate state-dependent service rates in staffing and when using the more straightforward approaches such as staffing based on the average service rate might not be problematic. We also investigate modifications to the SIPP approach that will lead to more reliable staffing under our systems of interest.

# The Psychology of Virtual Queue: When Waiting Becomes Less Like Waiting

Kejia Hu<sup>1</sup>, Xun Xu<sup>2</sup>, Qu (Leo) Ao<sup>1</sup>

*1 Vanderbilt University, USA*

*2 California State University Stanislaus, USA*

**Abstract** In this study we examine the effect of Virtual Queue (VQ) on customer complaints and overall satisfaction. We find a positive direct effect exists, but not a negative spillover effect. That is, VQ significantly reduces customers' complaints about pre-process perceived waiting and increases their overall satisfaction but does not increase their in-process waiting complaints. In addition, we find the positive effects of VQ adoption are relatively immediate, rather than lagged. Moreover, the effects of VQ are amplified if providers are perceived to have low value or high substitutability.

# Dynamic Inter-day and Intra-day Scheduling

Christos Zacharias<sup>1</sup>, Nan Liu<sup>2</sup>, Mehmet Begen<sup>3</sup>

*1 University of Miami, Coral Gables, USA*

*2 Boston College, Massachusetts, USA*

*3 Western University, London, Canada*

The simultaneous consideration of dynamic inter-day and intra-day scheduling decisions is an established theoretical and practical problem that has remained open due to its highly stochastic nature, complex structure, and the curse of dimensionality. We develop the first analytical model and associated theoretical results addressing this joint problem within a computationally tractable optimization framework with theoretical performance guarantees.

Our model was designed with the intention of bridging two seemingly independent streams of research (inter-day literature and intra-day literature), and to leverage their latest theoretical developments in tackling the joint problem. We build connections between the two independently evolved streams of research by proving novel theoretical results in discrete convex analysis regarding constrained multimodular function minimization. These theoretical results are standalone, independent of our model and underlying problem. They relate to the theory of discrete optimization and its applications within and beyond the area of appointment scheduling.

# The Adoption of Robot-Assisted Surgery by Surgeons: A Mixed-Methods Study

Taranga Datta<sup>1</sup>, Narain Gupta<sup>2</sup>, Soumyakanti Chakraborty<sup>3</sup>,  
Sumanta Basu<sup>3</sup>, Megha Sharma<sup>3</sup>, Arunava Roy<sup>4</sup>

*1 Indian Institute of Management Calcutta, India*

*2 MDI Gurgaon, India*

*3 IIM Calcutta, India*

*4 Medica Superspecialty Hospital, Kolkata, India*

The emergence of surgical technology has led to a paradigm shift in the way treatments are delivered to patients and how surgeons operate. Surgeons are benefited from the precision and control enabled by surgical technology but are discouraged due to the lack of haptic feedback and long, expensive training programmes. However, there are only a handful of studies that have examined the adoption or resistance of technology in surgical settings, resulting in knowledge gaps. In India, approximately 70% of surgeries are performed as open procedures at present, which is expected to change very soon, with the Indian robotic surgery (RAS) market projected to reach Rs. 26 billion in 2024. Thus, the focus of this study is to investigate the potential drivers behind the surgeons' adoption of or resistance to RAS. We rely on a mixed-methods empirical design for this study. Firstly, we perform fuzzy-set qualitative comparative analysis (fsQCA) of interview data collected from a small sample of Indian robotic surgeons to draw conclusions about their adoption/ non-adoption intention and their intention to recommend RAS to peers. Secondly, we conceptualize a model to explain the adoption of and resistance to RAS by building on the Extended Unified Theory of Acceptance and Use of Technology (UTAUT2) and the Innovation Resistance Theory (IRT). We test our model on a large sample of surgeons and draw conclusions based on the structural equation modelling framework. Our findings contribute to the innovation resistance literature as well as the healthcare technology adoption literature in emerging markets.

# Appointment Scheduling for Multiple Servers

Alex Kuiper, Robert Lee

*University of Amsterdam, Amsterdam, The Netherland*

Appointment schedules in essence balance supply and demand and are often employed in settings where resources are scarce and thus a high utilization is realized, e.g. healthcare. Whereas most of the existing literature focuses on the single-server case, a framework is developed to study appointment scheduling in multi-server settings.

Relying on phase-type approximations, general service-time distributions are modeled, which are fed into a recursive approach allowing evaluation and optimization of an objective function which balances expected waiting times and idle times. Studying optimized schedules for multiple servers reveals that the start and end of a session can deviate greatly from the dome-shape pattern as established for the single-server case. Furthermore a comparison of various multi-server set-ups shows that significant performance gains can be achieved when servers are pooled. This allows an explicit quantification of the cost of continuity of care. In addition, session overtime as well as early finish of servers can be incorporated in the approach; the benefits of the additional flexibility that a multi-server setting provides are summarized.

For the stationary plateau of the dome, to which the optimal inter-arrival times converge, steady-state appointment schedules are obtained by exploiting the embedded Markov chain, which are shown and argued to converge quickly to optimal solutions obtained in a heavy-traffic regime. In this regime, algebraic solutions are derived, which provide interesting managerial guidelines when pooling of servers is considered in appointment scheduling.

# Investigating Inventory Pooling Schemes in Healthcare: Evidence from an Emerging Market

Asmae El Mokrini<sup>1</sup>, Tarik Aouam<sup>2</sup>, Kafa Nadine<sup>3</sup>

*1 International University of Rabat, Morocco*

*2 Ghent University, Belgium*

*3 Kedge Business School, France*

In supply chain management, inventory pooling refers to individual demand and/or lead time variabilities being consolidated through aggregation to lower the total variability they produce, and hence uncertainty and risk (Oeser and Romano, 2021). Unlike industry, healthcare management has been slow at implementing effective business logistics concepts such as inventory pooling or aggregation. Despite its proven success and efficacy in different sectors and industries (Berman et al., 2011; Schmitt et al., 2015; Yang et al., 2021), inventory pooling has been rarely investigated and applied to the healthcare sector (Wu et al., 2015; Strozzi et al., 2019).

Sharing inventory in the pharmaceuticals supply chain can potentially enable public policy makers to create important savings that can be allocated to significant health challenges and needs in emerging markets (Ramanathan et al., 2014). However, pooling comes at a cost, which needs to be quantified to assess the actual savings. Pooling costs include setting and operating an information system, inventory, and transportation management. Quantifying these costs is also important since public organizations especially in emerging or developing economies are reluctant to allocate such budgets, despite the savings they can provide. Investigating the literature shows that most studies do not take into consideration costs of inventory pooling implementation, failing to quantify and factor them into their models.

This paper aims to bridge this gap and investigate the potential and value of inventory pooling in the healthcare sector of an emerging market while factoring in inventory pooling costs. It presents a model that captures the cost of pooling to find the optimal set of demand points to achieve a cost-efficient scheme balancing pooling costs and savings. It incorporates a multi-phase approach to determine a tailored aggregation strategy for policy makers to design a supply chain inventory pooling plan taking into consideration budget constraints. The first phase elaborates a method to quantify pooling costs considering the management system required for regions, demand-points pooled, and products pooled. This measure depends on several elements, including the logistics functions to be operated (storage and transportation) and the information system required. The second phase formulates the pooling problem with the objective of minimizing inventory costs. Given multiple products, regions, and demand points, the purpose is to determine the optimal safety stock pooling scheme. The problem is defined

as a mixed integer conic quadratic program, which is then transformed to a convex problem. In the third phase, an analysis of resulting pooling schemes is conducted.

We apply the proposed model to the real case of the Moroccan supply chain of pharmaceuticals and analyze inventory pooling schemes under different budget allocations to investigate how regional and product disparities affect costs and inventory pooling decisions. The results show that pooling configuration differs greatly when varying pooling budget, and is affected by product type, regional population density, income per capita, and urbanization rate. We first show that with respect to the number of regions being pooled, under a given level of variability, the savings of pooling do increase with the number of locations being pooled. If policy makers in healthcare are risk averse and allocate a minimum budget, then savings will vary between 5 to 10%. If they are willing to allocate a large budget to implement pooling at the national level, savings can increase up to 49%. Overall, pooling can be interesting in emerging markets or developing countries where urbanization rate is very high, making population more condensed and flows of product easier due to short distances and smaller transportation network.

## References

- Berman, O., Krass, D., and Mahdi Tajbakhsh, M. (2011). On the benefits of risk pooling in inventory management. *Production and operations management*, 20(1):57–71.
- Oeser, G. and Romano, P. (2021). Exploring risk pooling in hospitals to reduce demand and lead time uncertainty. *Operations Management Research*, 14(1):78–94.
- Ramanathan, U. (2014). Performance of supply chain collaboration—a simulation study. *Expert Systems with Applications*, 41(1):210–220.
- Schmitt, A. J., Sun, S. A., Snyder, L. V., and Shen, Z.-J. M. (2015). Centralization versus decentralization: Risk pooling, risk diversification, and supply chain disruptions. *Omega*, 52:201–212.
- Strozzi, F., Garagiola, E., and Trucco, P. (2019). Analysing the attractiveness, availability and accessibility of healthcare providers via social network analysis (sna). *Decision support systems*, 120:25–37.
- Wu, D., Rossetti, M. D., and Tepper, J. E. (2015). Possibility of inventory pooling in china's public hospital and appraisal about its performance. *Applied Mathematical Modelling*, 39(23–24):7277–7290.
- Yang, C., Hu, Z., and Zhou, S. X. (2021). Multilocation newsvendor problem: Centralization and inventory pooling. *Management science*, 67(1):185–200.

# A Queueing-Theoretic Framework for Evaluating Transmission Risks in Service Facilities During a Pandemic

Kang Kang<sup>1</sup>, Sherwin Doroudi<sup>1</sup>, Mohammad Delasay<sup>2</sup>,  
Alexander Wickeham<sup>1</sup>

*1 University of Minnesota, Minnesota, USA*

*2 Stony Brook University, Stony Brook, USA*

We propose a new modeling framework for evaluating the risk of disease transmission during a pandemic in small-scale settings driven by stochasticity in the arrival and service processes, i.e., congestion-prone confined-space service facilities. We propose a novel metric, *system-specific basic reproduction rate*, inspired by the “basic reproduction rate” concept from epidemiology, which measures the transmissibility of infectious diseases. We derive our metric for various queueing models of service facilities by leveraging a novel queueingtheoretic notion: sojourn time overlaps. We showcase how our metric can be used to explore the efficacy of a variety of interventions aimed at curbing the spread of disease inside service facilities. Specifically, we focus on some prevalent interventions employed during the COVID-19 pandemic: limiting the occupancy of service facilities, protecting high-risk customers (via prioritization or designated time windows), and increasing the service speed (or limiting patronage duration). We discuss a variety of directions for adapting our transmission model to incorporate some more nuanced features of disease transmission, including heterogeneity in the population immunity level, varying levels of mask usage, and spatial considerations in disease transmission.

**Keywords:** COVID-19 pandemic, Service systems, Queueing theory, Basic reproduction rate, Disease transmission

# Approximation Schemes for the Joint Inventory Selection and Online Resource Allocation Problem

Xingxing Chen<sup>1</sup>, Jacob Feldman<sup>2</sup>, Seung Hwan Jung<sup>3</sup>, Panos Kouvelis<sup>2</sup>

*1 University of Richmond, USA*

*2 Washington University in St Louis, USA*

*3 Yonsei University, Korea*

In this paper, we introduce and study the joint inventory selection and online resource allocation problem, which is characterized by two sequential sets of decisions that are irrevocably linked. First, a decision maker must select starting inventory levels for a set of available resources. Subsequently, the decision maker must match arriving customers to available resources in an online fashion so as to maximize expected reward. We first study the problem in its most general form, before focusing on a specific version that arises at Anheuser Busch InBev (ABI). This particular application of our general setting is referred to as the ABI Trailer Problem, and it considers how ABI ships its beer to vendors via third party delivery trucks. In this problem, ABI must select the weights of preloaded trailers of beers, which are then matched in an online fashion to arriving third party delivery trucks. For the general setting, we develop simple and easy-to-implement approaches that come with robust worst-case performance guarantees. For the ABI setting, we reveal a simplifying structural property related to the optimal matching policy, which gives rise to a natural adaptation of our original approach. We test the efficacy of these policies through extensive numerical experiments, where we find that our approaches are either near-optimal or improve upon state-of-the-art benchmarks. In particular, using a data set from ABI, we are able to generate instances of the ABI Trailer Problem, on which our algorithm has the potential to yield revenue improvements in the range of millions of dollars per year.

# Managing Material Shortages in Project Supply Chains: Inventories, Time Buffers and Supplier Flexibility

Xingxing Chen<sup>1</sup>, Panos Kouvelis<sup>2</sup>, Yu Amy Xia<sup>3</sup>

*1 University of Richmond, USA*

*2 Washington University in St Louis, USA*

*3 College of William and Mary, USA*

We consider a two-stage project supply chain with a downstream project firm producing an engineer-to-order (ETO) complex product or a make-to-order (MTO), low-volume, customized industrial product as a project, and an upstream supplier supplying key material to the project firm. The project is subject to unplanned material shortages due to project disruptions (e.g., engineering design changes, quality problems, low yield) that impact both project duration and material demand. The project firm has to carefully decide its promised project due date to its customer, against which harsh penalties will be assessed, as well as material orders that account for shortages caused by project disruptions. In our benchmark model, the project firm orders via a single-order wholesale price contract from the supplier, and uses a backup capacity as an expediting recourse to material shortages. Our analysis reveals the interdependency of project due date and ordering decisions for the project firm, with the interdependency characterized by the substitution behavior between time buffers for the due date and inventory buffers for project material.

In most practical settings, project firms order from contracted suppliers via a flexible wholesale price contract, which incentivizes suppliers to carry safety stocks to be used by project firms against material shortages. The production decision of suppliers under this contract, mostly driven by the incentive terms in the contract, will then have an impact on the project firm's project due date and ordering decisions. The complex optimization of due date, ordering, and production decisions within the chain reveals interesting insights for risk management in project supply chains. For MTO projects, risk-sharing with suppliers on project material is less important for the chain, with the coordinated action of the project manager (setting a project due date) and the procurement manager (ordering material from suppliers) being the key to managing material shortage risks. In contrast, for ETO projects, risk-sharing with contracted suppliers assumes critical importance. Project firms should fully leverage their ability to optimally set project due date and exploit their risk-sharing relationship with contracted suppliers.

# Robust Two-Period Inventory Management with Clearance Pricing

Zhao Qitong, Wang Yuan

*Singapore University of Social Sciences, Singapore*

In this paper, we consider a two-period joint pricing and inventory management problem for fashion goods where a retailer needs to decide the order quantity and first-period price before the selling season and a clearance price at the beginning of the second period. This problem is showed to be non-convex and thus computationally intractable. To tackle this, we first solve the deterministic model and adopt a distributionally robust approach to solve the stochastic model. Under some mild assumptions, we theoretically characterize the worst-case policy and the related gap of the robust model to the deterministic model. We also reformulate the general distributionally robust optimization model into a second order conic optimization model. Throughout extensive numerical study, we explore some managerial insights, and demonstrate the superiority of the robust pricing and inventory policies.

# Retailers Behaviour in Anticipation of Supply or Demand Disruptions: A Systematic Literature Review, Synthesis, and Future Research Agenda

Anannya Gogoi, Ashutosh Sarkar

*Indian Institute of Management Kozhikode*

Motivated by the rising panic buying studies during the COVID-19 pandemic and the resultant need for change in the conduct of retailing business, we looked into the possible behavioural changes of retailers as a result of customers' panic buying and supply shortage during disruptions. We employed an SLR methodology to synthesize, identify, and integrate the findings from the literature on panic buying from the fields of marketing, consumer research, and quantitative research or operations management. A majority of the studies in the prior literature focused on consumers' panic buying behaviour which indicated the possibility of a dearth of research on retailers' behaviour. This SLR helped to identify key research themes, potential gaps, and possible avenues for future research. We have identified key factors associated with the retailers' behaviour such as retailers' panic buying or panic ordering arising due to customers' behavioural changes. Subsequently, price regulation and purchase regulation were identified as important strategies to control demand-side disruptions. To account for the supply-side disruptions, retailers have adopted different mechanisms such as ordering strategies, labour management, alternate transportation networks, pivot to new goods, services & technologies. This SLR investigated the factors that mitigate the impact of a supply shortage or surge in demand during times of crisis and helped in developing a viable supply chain framework for retailers. This framework tries to establish feasible prescriptions for the respective stakeholders to design an agile (short term) as well as a resilient and sustainable (long term) supply chain in the face of uncertainty.

# Integrated Material and Transportation Planning to Optimize Efficiency and Robustness Across Supply Chains

Henriette Koch, Nóra Maleczki, Greca Manuzzi

*4flow AG, Germany*

Kinaxis and 4flow partnered to build a native embedded software application that enables automatic integration of transportation optimization within material requirement planning. In doing so, we provide material planners with the tools to schedule their orders while considering real-life logistics constraints which is to date often still neglected in this process. Considering these constraints early in the planning process eventually leads to much more efficient loads to be built, thus minimizing total logistics costs and CO2 emissions.

In this talk, we want to present the real-life constraints we consider, the algorithmic approaches we use to tackle the problem, and the benefits the solution provides to our customers.

# Digital Twin in Smart Warehouse Design and Optimization

Jessica Wang Yuan, Wu Zhenyong

*Singapore University of Social Sciences, Singapore*

Current new generation information technologies lead to high flexibility and agility in the warehouse system. The digital twin technologies have caught the attention of industry and academia. This paper proposes a digital twin-driven design and optimization approach for smart warehouse system. A method for digital twin-driven warehouse design is developed to aggregate from physical warehouse system and to map to the virtual model. An optimization model aiming to timely optimise goods packing and storage assignment is proposed to integrate to the digital twin system. A case study on a real warehouse design is provided to validate and illustrate the proposed approach. With the development of smart warehouse, traditional warehouses are using more digital technologies to warehouse operation and optimization. Traditional warehouse design methods are not able to consider the dynamic behaviours of designed warehouse. The application of digital twin can support to solve this problem as it has the fidelity to physical warehouse. A digital twin-driven warehouse design framework is proposed including the dimension definition, digital twin module design, module relationship and the establishment of the virtual model. A case study is provided by using the digital twin in warehouse design. Through the digital twin model, the best design solution can be found. Moreover, the designers can compare the performance of virtual warehouse under different solutions and scenarios. Finally, digital twin-driven warehouse can accelerate the design cycle by avoiding lengthy testing attributed to the assessment of virtual warehouse.

# A Discrete-Event Simulation-Optimization Approach to Assess Resilient Pharmaceutical Supply Chains

Jonathan Cuevas Lopez<sup>1</sup>, Catherine Azzaro-Pantel<sup>1</sup>,  
Sofía De-León Almaraz<sup>2</sup>, Constantino Gerardo Moras Sanchez<sup>3</sup>,  
Alberto Alfonso Aguilar Lasserre<sup>3</sup>

*1 Laboratoire de Génie Chimique, Université de Toulouse, CNRS, INPT, UPS, Toulouse, France*

*2 Corvinus University of Budapest, Budapest, Hungary*

*3 Tecnológico Nacional de México, Campus Orizaba Ver. Mexico*

A pharmaceutical supply chain (PSC) is a demand-driven system, that provides medicines covering every activity from new product development to delivery to the hospital, retail pharmacy or patient. As products linked to the health of the population, any disruption in its drug supply chain can cause a severe crisis.

The scientific objective of this work is to propose a methodological framework to model and optimize a PSC targeting inventory optimization. It involves a two-step approach based on:

1. Discrete-event simulation as a modeling approach widely used in decision support tools for logistics and supply chain management: this method has been selected here to model the dynamic behavior of the PSC due to its versatility and effectiveness.
2. Genetic algorithms (GA) used an outer optimization loop in combination with discrete-event simulation: they have proven their efficiency in a broad range of engineering complex problems where the use of mathematical programming approaches has reached its limits.

This hybrid strategy has been implemented in the SIMIO Simulation Modeling framework based on Intelligent Objects. The choice was also motivated by the integration of optimization applications such as OptQuest, which includes a library of genetic algorithms. The case study is based on a generic yet fictitious supply chain determined from an investigation carried out by the FusionOps group through big data analysis. The model is formulated as a bi-objective optimization approach in which the objective functions are the maximization of the service level and the minimization of the inventory. The use of these tools can be an effective aid to scenario development and system resilience.

# Ordering COVID-19 Vaccines for Social Welfare under Information Updating: Optimal Dynamic Order Policies and Vaccine Selection

Xiaoyan Xu<sup>1</sup>, Suresh P. Sethi<sup>2</sup>, Sai-Ho Chung<sup>1</sup>, Tsan-Ming Choi<sup>3</sup>

*1 The Hong Kong Polytechnic University, Hong Kong*

*2 The University of Texas at Dallas, USA*

*3 National Taiwan University, Taiwan*

During the early stage of the COVID-19 pandemic, governments faced a variety of vaccine choices having different efficacies and available at different time points. Demand for vaccination is highly volatile and depends on the disease's infectiousness. In this paper, we consider a two-stage vaccine ordering problem of a government from a first and only supplier in the first stage and either the same supplier or a new second supplier in the second stage. Between the two stages, information regarding the number of potential demand for vaccine is collected and used to update the forecast. Using dynamic programming, we derive the government's optimal vaccine ordering policy. We find that the government should select its vaccine supplier based on the infection rate of the disease in the country/region. Specifically, when the infection rate is low, the government should order nothing at the first stage and order from the supplier with a higher efficacy level in the second stage. When the infection rate of the disease is high, the government should order vaccines at the first stage and switch to the other supplier with lower efficacy level at the second stage. Otherwise, ordering from the same supplier at both stages is optimal. To generate more insights, we extend our model to examine (i) the value of blockchain adoption and (ii) the impact of vaccines' side effects.

# Multi-Echelon Inventory Management with Component Substitution Using Stochastic Dual Dynamic Programming

Yossiri Adulyasak<sup>1</sup>, Simon Thevenin<sup>2</sup>, Jean-François Cordeau<sup>1</sup>

*1 HEC Montreal, Canada*

*2 IMT-Atlantique, France*

In this talk, we present the multi-level inventory management problem with component substitution under demand uncertainty arising in the context of production planning and distribution management. The consideration of component substitution naturally allows risk pooling and reduces operating costs. We propose a multi-stage stochastic programming approach which is solved by the stochastic dual dynamic programming (SDDP) to tackle this problem. Since implementations of multi-stage stochastic programming models remain highly challenging from the computational perspective, we consider various improvements of SDDP as well as efficient heuristics which allow us to tackle a large-scale instance with up to  $20^{**}(10)$  possible scenarios. We empirically validate the value of the stochastic solutions through extensive computational experiments using well-known instances from the literature. We also present insights how the multi-stage stochastic optimization framework can help improve the solution quality in a multi-stage decision process under uncertainty and enable significant cost savings.

# Take it or Leave it: Renegotiating in Collaborative Product Development

Sara Rezaee Vessal<sup>1</sup>, Timofey Shalpegin<sup>2</sup>

*1 ESSEC Business School, France*

*2 Auckland University, New Zealand*

The suppliers might sometimes develop a new product of the quality inferior to the buyer's expectations. We model the possibility of conditional acceptance of such products by the buyer. Our goal is to track the effect of conditional acceptance on the supplier incentives to exert product development efforts. We construct a non-cooperative sequential game with risk-neutral players and analyze their equilibrium strategies. We find that implementing the conditional acceptance policy indeed affects the supplier incentives if the product is of relatively high value to the buyer. The effect direction depends on the cost of effort and project success probability.

# Designing Networks Resilient to Clique Blockers

Foad Mahdavi Pajouh<sup>1</sup>, Haonan Zhong<sup>2</sup>, Oleg Prokopyev<sup>3</sup>

*1 Stevens Institute of Technology, USA*

*2 Kunming University of Science and Technology, China*

*3 University of Pittsburgh, USA*

The problem of designing a network that is resilient to clique blocking (DNRCB) is to find the minimum cost of connecting a set of vertices such that the cost of blocking cliques in the obtained network is not less than a given constant. The cost of blocking cliques in the obtained network is the minimum cost of blocking vertices such that the weight of all cliques in the remaining network is less than a given constant. We addressed the computational complexity of this problem, proposed an integer programming (IP) formulation, and solved the IP by enforcing constraints in a lazy fashion. We also proposed an exact combinatorial branch and bound algorithm to solve this problem.

# The Impact of Covid Uncertainty on Supply Chain Performance in Emerging Economy

Md Shah Newaz<sup>1</sup>, Muhammad Khalilur Rahman<sup>2</sup>,  
Andrea Appolloni<sup>1</sup>, Mina Hemmati<sup>2</sup>

*1 University of Rome, Tor Vergata, Italy; nwzmsh01@uniroma2.it,  
andrea.appolloni@uniroma2.it*

*2 Universiti Malaysia Kelantan, Malaysia; khalilur.r@umk.edu.my,  
hemmati.minaum@gmail.com*

**Purpose:** In this Covid-19 era reassessing the supply chain (SC) at the firm level is one of the plausible solutions to cope with this dreadful Covid uncertainty, where supply chain flexibility, integration and organizational ambidexterity can play a significant role in this paradigm. Thus, the **aim** of this study is to explore how the Covid uncertainty impacts the SC performance of manufacturing and service industries in emerging economies? And what is the role of SC flexibility, SC integration, SC agility and organizational ambidexterity in this complex mechanism?

**Method/Design:** Using the cross-sectional design, and a self-administered questionnaire, 405 responses were collected from Malaysian manufacturing and service firms. Partial least square-based structural equation modelling is employed to test the impact of Covid uncertainty on supply chain performance in manufacturing and service industries.

**Findings:** The results of the hypothesis test show that Covid uncertainty reflects the SC performance via organizational ambidexterity and SC integration, while SC flexibility does not have a significant impact on the SC integration. Hence, organizational ambidexterity and SC integration act as the mediators amid Covid uncertainty to impact the SC performance, while there persists no chain mediation effect from SC flexibility and SC integration in this mechanism. Furthermore, SC agility moderates the relationship between Covid uncertainty and SC flexibility while for organizational ambidexterity, SC agility does not have any moderating effect.

**Originality/Contribution:** This study bridges the gap in SC literature by analysing the intertwined complex relationships amid COVID uncertainty and its impact on SC performance from a holistic perspective taking the moderation and mediation effects into account in the context of an emerging economy.

# Relationship Between Digitalisation and Supply Chain Capabilities – Analysis Based on Manufacturing Industry Survey Data

Anna Freund, Judit Nagy

*Corvinus University of Budapest, Budapest, Hungary*

The focus of the study is the relationship between supply chain capability and digitalisation. In addition to the physical, financial, human, technological and organisational resources a company has, supply chain capability also means the ability to collaborate, to be resilient or even to share information.

We use data from the 2019 survey of the Competitiveness Research Centre to investigate the relationship between supply chain capabilities and digitalisation. We hypothesise that digitalisation can support supply chains in coordinating their relationship and operational processes.

In order to provide a structured interpretation of the topic, a quantitative analysis was conducted. Our research question focuses on the relationship between supply chain capabilities and digitalisation. We used Anova and cluster analysis to investigate the relationship between the factors of the database.

The results of the analysis suggest that digital development is influencing and deepening the management of supply chain relationships. As the range of data shared and information processed is expanding, transparency and operational security improve. The extension of data analysis and sharing is also relevant for process alignment and have positive effects on companies' business performance, e.g. competitiveness, profitability. In addition, logistics capabilities show an improvement, which can be seen as a success factor within the whole supply chain. The results allow supply chains to target digital improvements to develop a specific capabilities. The assessment of digital solutions is usually done at the enterprise level, but in this study, we assess the impact at the supply chain level and identify the impact on capabilities.

**Keywords:** manufacturing industry, supply chain capabilities, digitalisation

# Optimizing Investments in Resilience for Supply Chain networks

Kai Trepte<sup>1</sup>, James B. Rice<sup>1</sup>, Walid Klibi<sup>2</sup>

*1 MIT Center for Transportation & Logistics , USA*

*2 Center of Excellence for Supply Chain Innovation & Transportation (CESIT), Kedge Business School, France*

Our work has been inspired by a collaboration with an industrial partner that engaged in an action research initiative to assess, quantify and align resilience investments and actions with the vulnerabilities faced by their supply chain network. Our work makes a connection between risk assessments, operational outcomes and investments in supply chain resilience. We propose a methodology that starts with scenarios building and generation, then network optimization, and ends with resilient network designs assessment and selection. We will emphasis on the sequential decision problem that is faced at the optimization phase, when several periods for investments in resilience must be considered. Managerial insights will be shared on the solvability challenges and the managerial acceptability of the design solutions when such methodology is applied in practice.

# Project Networks and Disruption Externalities

Juan Camilo Serpa<sup>1</sup>, Vibhuti Dhrigra<sup>2</sup>, Harish Krishnan<sup>3</sup>

*1 McGill University, Canada*

*2 York University, Canada*

*3 University of British Columbia, Canada*

Projects involve several participants---e.g., clients, contractors, subcontractors---all working on multiple projects concurrently and allocating resources across them. Such interdependencies give rise to a network of otherwise unrelated projects. After mapping out the largest project network ever, we track the timelines of 2.61 million infrastructure projects involving 150,000 participants. We then show that a seemingly localized disruption affecting only one project site eventually causes delays and penalties across unrelated projects. This is because self-interest may drive participants to opportunistically reallocate resources into disrupted projects, at the expense of other projects, triggering a domino effect of further reallocations. Thus, the costs of a localized disruption end up being levied across unrelated participants in the project network, instead of being fully absorbed by the directly disrupted project. Performance-based contracts that reward contractors based on timeliness exacerbate these externalities by promoting self-interested resource reallocation among participants.

# Supplier Selection Under Consideration of Risk and Cost - A Set Covering Model

Marcus Brandenburg

*Flensburg University of Applied Sciences, School of Business, Flensburg, Germany*

Supplier selection is a complex and decisive task of strategic supply chain management. When compiling the supplier pool, conflictive aspects of risk and performance need to be taken into account. In particular, cost for managing the relations to suppliers need to be considered as well as the risk of supplier breakdown and resulting supply disruptions. A small and streamlined pool of suppliers that may result from a single sourcing strategy causes lower costs but increases the risk of major stoppages. Broadening the supplier pool, e.g. by integrating backup suppliers or following a multiple source strategy, helps mitigating the supply risk but increases the resulting network cost. A resilient and efficient supply network could be obtained by resolving the tradeoff between risk and cost.

The proposed study deals with the problem to select a set of suppliers that minimizes the cost and the risk of supply disruptions while covering the whole set of required supplies. Most prominent decisionmaking techniques for supplier selection comprise MCDM, mathematical programming and artificial intelligence. In the proposed study, a set covering problem formulation is chosen to model the supplier selection problem. In addition, heuristic approaches are applied to solve the formulated problem and compared at numerical test instances.

**Keywords:** Supplier selection, Set covering, Graphs and networks, Risk and resilience, Heuristics.

# Equilibria in Interdependent Natural-Gas and Power Markets: An Analytical Approach

Seyedamirabbas Mousavian<sup>1</sup>, Beheshteh Raouf<sup>1</sup>, Antonio Conejo<sup>2</sup>

*1 Clarkson University, USA*

*2 Ohio State University, USA*

Natural-gas and power systems and their corresponding markets have evolved over time rather independently. However, both systems are increasingly interdependent since combined cycle gas turbines (that use natural gas to produce electricity) increasingly couple them together. Therefore, suitable analysis techniques are most needed to comprehend the consequences on market outcomes of an increasing level of integration of both systems. There is a vast literature on integrated natural-gas and power markets assuming that the two markets are operated centrally by a single operator. This assumption is often not true in the real world, which necessitates developing models for these interdependent yet independent markets. In this vein, this paper addresses this gap in the literature and provides analytical Nash-Cournot equilibrium models to represent the joint operation of natural-gas and power markets with the assumption that the market participants in each market make their own decisions independently seeking maximum profits, as often is the case in the real world. We develop an analytical equilibrium model and apply the Karush-Kuhn-Tucker (KKT) approach to obtain Nash-Cournot equilibria for the interdependent natural-gas and power markets. We use a double-duopoly case to study the interaction of both markets and to derive insightful analytical results. Moreover, we derive closed-form analytical expressions for spot-market equilibria in both natural-gas and power markets, which are relevant and of practical significance for decision makers. We complement the duopoly-duopoly study with a detailed sensitivity analysis.

# Purchasing and Sustainability Functions Integration for Green Public Procurement. Evidence from an Italian Case Study

Daniele Binci, Valentina Bianchini, Andrea Appolloni

*University of Rome "Tor Vergata", Italy*

**Purpose** We aim to provide empirical evidence about the cross-functional integration between Purchasing and Sustainability in public administrations. Although Purchasing and Sustainability are key functions for sustainable procurement implementation, there is a dearth of literature investigating these functions integration in the public organizations and their effects on sustainable public purchases.

**Design/methodology/approach** By conducting a case-study analysis in a Regional-level Italian Public administration, the authors adopted the Social Exchange Theory (trust, collaboration, reciprocity, perceived justice, interdependence, power asymmetry and opportunism) to investigate the "synergy effect" between Purchasing and Sustainability functions along the implementation of green public procurement (GPP). The pilot case was chosen as a purposive sample with GPP experience, who could provide us with the most relevant information, direct knowledge and perceptions about GPP implementation.

**Findings** Our analysis revealed that the integration between Procurement and Sustainability functions is dependent on organizational maturity level. The responsibility attribution is identified as the essential element of such a change. Finally, sustainability is not always prioritized on cost, time and quality, so if a sustainable purchase becomes more expensive or time-consuming, it is not executed.

**Originality/Value** To the best of our knowledge, this is the first study analyzing the cross-functional integration between Purchasing and Sustainability by using the theoretical lens of SET. Moreover, the study provides useful insights for public administrations facing the challenges of implementing GPP.

# Sustainable Public Procurement at Global Level. A Systematic and Critical Review

Valentina Bianchini, Andrea Appolloni

*University of Rome "Tor Vergata", Italy*

Through a systematic literature review this paper aims at furthering the understanding of the role that Public Procurement can play as a leverage for sustainability in relation to Global Sourcing (GS). We found that the product and process-based practices adopted by public buyers to ensure sustainability of global suppliers influence the public buyersupplier relationship. Furthermore, we found that the implementation of these practices is affected by internal and external variables influencing the sustainability outcomes. This allowed us to present a conceptual framework on SPP & GS relationship and propose future research agendas to improve the understanding of the interactions among the two fields for sustainability outcomes.

**Keywords or phrases:** Sustainable Public Procurement; Global Sourcing; Sustainable Supply Chain Management.

# Exploring Retailer Door-step Delivery Strategy in a Competitive Environment of a Two-level Supply Chain

Nikunja Mohan Modak<sup>1</sup>, Peter Kelle<sup>2</sup>

*1 PalparaVidyamandir, Chakdaha, West Bengal, India  
nikunja.modak@gmail.com*

*2 Stephenson Department of Entrepreneurship & Information Systems  
Louisiana State University, Baton Rouge, LA, USA  
qm kell@lsu.edu*

The outbreak of covid-19 has a huge impact on the operations of the supply chain network. Several retailers open a new door-step delivery channel to address more customers during this pandemic. This work develops a mathematical model of a two levels supply chain consisting of a manufacturer and two competing retailers. The demand for the product depends on price and logistic service level. Under the Stackelberg-Cournot game setting, it determines the optimal decisions of the channel members. It examines the effect of logistic service level and other key parameters on optimal decisions. It also tests conditions for the successful operations of the door-step delivery channel. Finally, it proposed contracts for channel coordination for the mutual benefit of the channel members. Outcomes of the mathematical models are illustrated using several numerical examples and graphical representations.

**Keywords:** competitive Supply chain; door-step delivery channel; covid-19; Pricing competition; Logistic service.

# Smart Home Insurance: Collaboration and Pricing

Debajyoti Biswas, Sara Rezaee Vessal

*ESSEC Business School, Cergy, France*  
*debajyoti.biswas@essec.edu, rezaee@essec.edu*

“Smart Home Insurance” combines home insurance and smart home products at an attractive price, protecting customers from hazards and insurance companies from subsequent losses. In this paper, we analyse the insurer’s policy of offering different discounts (no, full or the same as insurance) on the price of a smart product along with discount on the insurance premium, and how it is impacted by the interaction between the insurer and the smart product manufacturer (SPM). We consider two market structures - (1) a dominant manufacturer (Stackelberg) and (2) both players with equal market power (Nash). We compare the players’ pricing and design decisions under no-contract, Wholesale-price contract, and Cost-sharing contract. We find that in the Nash setting, both players prefer a Wholesale-price contract with an exogenous wholesale price when the insurer offers a free smart product, whereas, in the absence of any interaction between the players, the SPM prefers the insurer to offer a discount on insurance only, provided the loss due to the hazard is very low or very high. In the Stackelberg setting, both players are indifferent to the insurer’s policy of offering any discount on the smart product combined with an insurance discount. Comparing contracts, we find that the SPM strongly prefers the Cost-sharing contract, when she is deciding the wholesale price. We numerically find that both players are always better-off when there is some interaction between them, irrespective of their relative market power, except when the insurer offers an insurance discount only, in the Nash setting

# Data-Driven Submodular Set-function Optimization: Theory and Applications in Assortment Planning and Recommender Systems

Daniel McGibney, Jigar Patel, Christos Zacharias

*Miami Herbert Business School, University of Miami, Coral Gables, FL, USA*  
*{dmcgibney,jigar.patel,czacharias}@bus.miami.edu*

Recommender systems and informed assortment planning facilitate the display of goods or services tailored to individual customer needs/characteristics, promote the visibility of assorted products, and revenue growth. We address the problem of optimal assortment and display of online search results for goods or services. The objective is to maximize the platform's revenue and customer engagement by leveraging the menu of displayed search results to users, subject to catering to their individual search criteria or characteristics. Our analysis is based on a detailed data set from a leading online platform. Assortment planning involves optimization over a utility set-function. For example, a supermodular utility function is related to complementary goods, and a submodular utility function is related to substitutes. By analyzing our data, we identify properties of our utility function and implement the proper optimization algorithm tailored to individual users. Recent advances in the discrete optimization field has enabled us to provide optimal or near-optimal algorithms in polynomial time to tackle the difficult problem of submodular function optimization

**Keywords:** revenue management; assortment planning; search optimization; submodular optimization *History:* created on 02 22 2022 at 02:22pm

# Supply Chain Vertical Competition and Product Proliferation under Different Power Structures

Lijue Lu, Mozart B. C. Menezes

*NEOMA Business School, France*

The strategic importance of product proliferation has been highlighted in the past decades. It is commonly believed that the increase in product variety can help firms with market segmentation, thus achieving better sales performance and higher profitability. However, product proliferation also suggests greater manufacturing complexity, heavier operation costs, and higher defect rate. Firms need to weigh up all the pros and cons to carefully choose the optimal number of products.

In this paper, we study a game in supply chain management in which pricing and product line depth decisions need to be made. We analyse different scenarios depending on which member has the first-mover advantage in terms of pricing and on which member has the power to determine the number of product variants that are put on sale. The objective of this work is to study the interaction between pricing and assortment strategies and to investigate how the power structure affects these decisions in a supply chain.

We characterize the Stackelberg and Nash equilibria for pricing and assortment games in different scenarios and propose a revenue-sharing scheme to achieve coordination. Unfortunately, like some other coordination mechanisms, this contract is applicable in limited cases, when the number of product variants is below the optimal (coordinated) channel level, but cannot reduce product proliferation. We finally discuss some managerial implications.

**Keywords:** Product Proliferation; Marketing; Pricing; Supply Chain Management; Game Theory

# The Impact of Online Product Reviews on Retailer's Pricing and Return Policy Decisions

Mehmet S. Altug

*George Mason University, Fairfax, USA*

After a purchase, customers increasingly feel more comfortable sharing their experience in the form of online product reviews. On the other hand, retailers offer lenient return policies that also help with customers' ex-ante valuation uncertainty. We consider a monopolist retailer that sells a new experience good over two periods and makes pricing and refund decisions. Because returns for these types of products are generally associated with inadequate functionality, a customer review mentioning a return experience generally creates a negative sentiment. Consequently, in this environment, a higher refund not only increases the volume of returns, but also creates more reviews with a negative sentiment. Using a framework in which the negative reviews are weighed more heavily, we show that the retailer offers even a more generous refund compared to the benchmark setting with no reviews. In a duopolistic competition, the overall sentiment of the on-line reviews are influenced by the refund and pricing decisions of both retailers. Interestingly, we show that the retailers make their returns even more lenient compared to not only the benchmark setting with no reviews, but also the monopolist retailer with reviews and the same salvage value. We show that our results remain robust under several extensions.

# Will Providing Return-Freight-Insurances Do More Good than Harm to DualChannel E-Commerce Retailers?<sup>a</sup>

Jiixin Lin<sup>1</sup>, Tsan-Ming Choi<sup>2</sup>, Yong-Hong Kuo<sup>1</sup>

*1 The University of Hong Kong, Hong Kong*

*2 National Taiwan University, Taiwan*

**Abstract** Today, e-commerce retailers commonly operate in a dual-channel mode. Return freight insurance (RFI) is an emerging measure to resolve online shopping disputes with product returns. If a consumer returns an insured product, the insurance company will compensate the consumer for the return-freight fee. In practice, we observe that some dualchannel e-commerce retailers offer RFI to consumers, while others do not. We build consumerutility-based analytical models to study the retailer's optimal pricing decisions and values of RFI. In the basic models, the proportions of store-type consumers and online-type consumers are exogenously given; we examine three cases, namely Case N (RFIs are not provided), Case R (retailer purchases RFI for consumers), and Case C (consumers pay for RFI). Comparing these three cases, we uncover that the retailer who purchases RFI for consumers does not necessarily charge a higher price. We show that if the RFI premium is sufficiently (moderately) low, it is more beneficial for consumers (the retailer) to pay for the RFI. We analytically prove that (i) when the product's salvage value is polarized or the return freight cost is low, using RFI can help increase consumer surplus (CS), (ii) when the salvage value is sufficiently high, the social welfare (SW) with RFI is higher than the case without RFI. In the extended models, we explore the situation in which consumers can decide whether to purchase RFI as well as the channel to buy the products. In this case, we find that (i) the retailer should provide RFI only when the product's cost, salvage value, and return freight cost are all high, and (ii) offering RFI can increase CS but hurt SW. These findings provide important managerial guidance to dualchannel e-commerce retailers on the optimal strategy with the use of RFI.

**Keywords:** Supply chain management; e-commerce; pricing; return freight insurance; dualchannel.

<sup>a</sup> We sincerely thank the editor and reviewers for their critical comments which help improve this paper a lot.

# Implications of Peer-to-Peer Collaborative Consumption on a Firm's Carbon Emission Abatement Level under Government Regulatory Policies

Tania Saha

*Indian Institute of Management Calcutta, Kolkata, India*

Does the existence of a peer-to-peer product sharing market that facilitates collaborative consumption among consumers influences a profit-maximizing firm's optimal carbon emission abatement investment level? Through this study, we explore the question for three different carbon emission reduction regulatory policies, carbon cap-and-trade, strict carbon cap and carbon tax which are imposed by the government?

# Innovative Business Models in Ocean-Bound Plastic Recycling

Opher Baron<sup>1</sup>, Gonzalo Romero<sup>1</sup>, Zhuoluo Zhang<sup>2</sup>, Sean Xiang Zhou<sup>2</sup>

*1 Rotman School of Management, University of Toronto, Toronto, Canada  
opher.baron@rotman.utoronto.ca, gonzalo.romero@rotman.utoronto.ca*

*2 CUHK Business School, The Chinese University of Hong Kong (CUHK), Shatin, N.T., Hong Kong  
zhangzhuoluo@link.cuhk.edu.hk, zhoux@baf.cuhk.edu.hk*

About 30 million tons of plastic waste, or 10% of the world's annual plastic production, reaches the oceans each year, most from developing coastal countries. We study novel business models that aim to address this pressing global problem. Firms aim at profitably recycling plastic to reduce ocean pollution while positively impacting local communities. These firms sell (a) plastic offsets and (b) segregated plastic. We introduce and analyze supply chain models of a firm partnering with a local plastic recycling supply chain to sell (a) or (b) or both. The firm aims to maximize a triple bottom-line objective that is a weighted sum of its profit, environmental impact, and social impact. We find that (a) or (b) bring profit to the firm and generate positive environmental and social impact while (b) gives a larger share of the local supply chain surplus to the collectors than (a). For the special case where the firm is a profit maximizer, it still generates strictly positive environmental and social impacts by selling (a) or (b) as long as the price of recycled plastic in the local market is not too high. Furthermore, when the firm sells both (a) and (b), it attains a higher objective value than (a) or (b) alone but could perform worse in each individual dimension of its triple bottom line. Additionally, the collectors obtain a higher share of local supply chain surplus than (a) but a higher or lower share than (b). We use empirical data to calibrate our models, numerically illustrate our main results, and unveil additional insights. We find that the firm may not always attain a higher objective value when selling both (a) and (b) than the sum of (a) and (b) implemented independently, while it can benefit more from the synergy between (a) and (b) when either has a large market potential. Interestingly, we find that an organization that employs a triple bottom-line objective instead of only profit can generate much larger environmental and social impact with only a slight reduction in its profit. Our model and results provide theoretical support and insights into some of the new initiatives for tackling global ocean plastic pollution.

**Keywords:** Sustainable operations, business model innovation, plastic recycling, triple bottom-line objective.

# Buy, Make-and-ally: How Plural Sourcing can Help Achieve Corporate Social Responsibility in Outsourcing Relationships

Xun (Bruce) Tong<sup>1</sup>, Miriam Wilhelm<sup>1</sup>, Shuo Wang<sup>2</sup>

*1 University of Groningen, the Netherlands*

*2 University of Edinburgh, UK*

Outsourcing promises economic benefits by leveraging labor arbitrage from low-cost sourcing countries, but it creates additional risks for firms as the geography of global supply chains shifts to institutionally weak countries. In this paper, we investigate how the choice of a plural sourcing strategy could alleviate this risk. Instead of choosing between make, buy, or ally, a plural sourcing strategy builds on the simultaneous combination of distinct governance forms, in our case, *make-and-ally* through strategic alliance. We argue that such a make-and-ally strategy can help overcome some of the *performance measurement problems* associated with managing corporate social responsibility. We consolidate a panel data consisting of more than 9,000 firm-year observations based on U.S. publicly-traded manufacturing firms (COMPUSTAT) and their strategic alliance information from the Security Data Company (SDC Platinum) database as well as corporate social responsibility performance from the Thomson Reuters's ASSET 4 ESG data. We address endogeneity issues by employing an instrument variable approach (both for the independent and moderating variables) with a Two-Stage Least Squares (2SLS) estimation. We first provide empirical proof that outsourcing (buy) indeed leads to economic benefits and has a deteriorating effect on a firm's CSR. We argue and show, however, that a firm's plural sourcing strategy can mitigate this negative relationship.

# The Implication of Quality Testing by Agri-Cooperative on the Profitability of Smallholder and Marginal Farmers

Biswas, Samir<sup>1</sup>, Preetam Basu<sup>2</sup>, Balram Avittathur<sup>1</sup>

*1 Indian Institute of Management Calcutta, India*

*2 Kent Business School, UK*

A recent paradigm shift in the agricultural supply chain is transforming efficiency-driven industrial agriculture into quality-driven sustainable farming practices. It creates new opportunities for the farmers to improve their income and livelihoods. However, the smallholders and the marginal farmers in the developing economies face numerous challenges that hinder them from benefiting from these opportunities. They lack modern scientific farming approaches due to fragmented landholding, financial hardships, lack of proper knowledge, and limited access to reliable market information. An agri-cooperative can help the farmers to improve their profitability by addressing some of these challenges. It can provide high-quality inputs, improved logistics, better infrastructure, financial help, and efficient farm management practices.

In this paper, we consider an agri-cooperative capable of improving the agricultural produce quality by providing the necessary infrastructure to adopt advanced testing methods that are expensive and beyond the reach of the individual farmers. The cooperative, in turn, benefits through a higher bargaining power in the market owing to its control over a larger production quantity accumulated from the farmers. It leads to higher revenue for the cooperative, which may transcend the participating farmers' income. Using a game-theoretic model between a cooperative and two farmers, we explore the feasibility of two different testing methods (individual testing and composite testing) offered by the cooperative, ensuring the desired quality of produce. We also determine the conditions under which the farmers avail testing services and join the cooperative. Our results provide policy recommendations for the cooperative and the farmers under different conditions.

# Social Innovation in Global Supply Networks: Non-Traditional Actors in Emerging Markets

Fahian Huq<sup>1</sup>, Ilma Nur Chowdhury<sup>1</sup>, Robert Klassen<sup>2</sup>

*1 Alliance Manchester Business School, UK*

*2 Ivey Business School, Canada*

Social innovations involve the development of novel solutions that achieve positive social change especially for low-income or underserved populations. Particularly in emerging markets, multinational firms in global supply networks offer an important means to address poor working conditions in suppliers, develop strong female leaders and improve healthcare availability for workers. Despite calls to do so by multiple stakeholders, these firms often lack the expertise and capabilities to ethically and effectively design and implement critical social innovations. To address these challenges, supply networks must bring together and leverage creative partnerships to create impactful social innovations – often anchored and led by non-traditional actors including non-governmental organizations and government development agencies. In this study, three in-depth cases in the Bangladeshi garments industry incorporating interviews from matching dyads of focal non-traditional actors and their local non-governmental partner organizations are used to explore the process for social innovation, whereby partnerships between non-traditional and traditional actors advance through four stages (i.e., ideation; partner selection; implementation; and evaluation) to achieve social value. Furthermore, our theoretical contributions advance understanding about two key capabilities - engagement and empathy - that enable the process of social innovation in emerging market supply networks and help focal organizations achieve significant positive social impact.

# Geopolitics of Clean Energy: Biofuels in the Pandemic's Aftershock

Flavio Pinheiro Martins<sup>1</sup>, Beatriz Papa Casagrande<sup>1</sup>,  
Luciana Oranges Cezarino<sup>2</sup>, Claudia Souza Passador<sup>1</sup>,  
Lara Bartocci Liboni<sup>1</sup>, Marcos Fava Neves<sup>1</sup>

*1 School of Economics, Business Administration and Accounting at Ribeirão Preto (FEA-RP) -  
University of Sao Paulo, Brazil*

*2 Department of Management at Ca' Foscari University Venice, Italy*

**Theoretical background.** Biofuels demand is expected to continue to increase in the global market. The momentum is induced by policies to fulfil climate action goals by retrofitting the complex and intersectoral energy industry. **Gap-Novelty-Relevance.** COVID-19 aftermath was expected to generate momentum toward climate action and thus clean energy; nevertheless, the wheel was steered once again due to the unexpected geopolitical turmoil in eastern Europe: the current crisis resurfaced some old trade-offs and put new synergies on the clean energy policies decisions. **Objective-RQ.** This study aims at scoping trade-offs and synergies in clean energy global sourcing disclosures, therefore answering the question: "How does biofuel linkages with geopolitical turmoil are being communicated in non-academic sources?". **Methods.** We used scoping review grounded on grey literature to map the systemic nature of the event. Data gathering focused on disclosure of the thematic in the leading news portals worldwide. Data were analysed with content analysis aid by an AI-powered text-mining tool (Leximancer). **Methods reasoning.** The up-to-the-minute nature of the context changes is reflected in the methods for data gathering, and the heterogeneous characteristics of the grey literature justify the qualitative analysis informed by text mining data inquiry. **Results.** Preliminary results indicate that the risk of supply disruption walks hand in hand with energy independence and climate action goals. The impacts linked to biofuels policy have been widely broadcasted and interwoven with both transition and established economies. **Conclusion.** Once again, there is communicated expectancy that the new momentum can be steered in the direction of sustainability transition, especially in the EU. **Theoretical and practical implications.** The novelty of the subject and the combination of methodologies can aid the advance of clean energy resiliency research. The results have a reporting aspect that can be used in public policy decision making.

# Impact of Blockchain Adoption backed by Knowledge Management for Operational Performance through Supply Chain Visibility

Mohsin Shahzad<sup>1</sup>, Ying Qu<sup>1</sup>, Abaid Ullah Zafar<sup>2</sup>, Xiangan Ding<sup>3</sup>,  
Andrea Appolloni<sup>4</sup>

*1 Dalian University of Technology, China*

*2 Shenzhen University, Shenzhen, China*

*3 Liaoning Normal University, Dalian, China*

*4 University of Rome Tor Vergata, Italy*

Blockchain technology is becoming more prevalent worldwide as it influences and enhances interconnectivity while facing various challenges related to the supply chain in the global market. Among the innumerable range of blockchain technology adoption (BCA), a study for knowledge acquisition and its effective application to optimize operational performance through supply chain visibility (SCV) in the Pakistan textile industry is still nascent. As, an effective BCA through knowledge management (KM) has become one of the most effective tools for long-term sustainability, competitiveness, and performance. Therefore, drawing on the resource-based view and technology acceptance model, this study seeks to underline the empirical relationships among KM, BCA, SCV, and firms' operational performance (OP). Data were collected from 289 respondents (senior, middle, and junior) level staff members from textile industries and analyzed by partial least square structural equation modeling (PLS-SEM). The empirical analyses indicated that KM significantly impacts BCA. BCA also positively affects SCV. Besides BCA, the KM also positively impacts OP. The mediation effect analysis indicated the significant partial mediating impact of BCA and SCV on the relationship of KM to operational performance. The study deepens our understanding and provides valuable insights to the managers of textile firms concerning the role of KM and BCA in achieving OP.

**Keywords:** Knowledge Management, Blockchain Adoption, Supply Chain Visibility, Operational Performance, Structural Equation Modeling

# Social Aspects Related to the Hydrogen Supply Chain Design and Deployment

Sofía De-León Almaraz<sup>1</sup>, Tamás Kocsis<sup>1</sup>, Catherine Azzaro-Pantel<sup>2</sup>,  
Zoltán Oszkár Szántó<sup>1</sup>

*1 Corvinus University of Budapest, Budapest, Hungary*

*2 Université de Toulouse, Laboratoire de Génie Chimique Toulouse Cedex 4 – France  
catherine.azzaropantel@toulouse-inp.fr*

The Sustainable Development Goals aim to ensure access to affordable, reliable and sustainable energy for all. Energy transitions will reshape the power sector in the coming decades with an increase in the use of renewable sources as the foundation of low carbon power generation with implications to all type of operations. Hydrogen is as a key energy carrier that could contribute to the energy security and can be coupled with renewable sources to store energy and provide flexibility. It can be used as a fuel in mobile/stationary applications and as a raw material in industry. The inclusion of sustainability criteria is crucial to ensure the design and deployment of a hydrogen resilient network, however, only a few studies include simultaneously the economic, environmental and social aspects when proposing a hydrogen supply chain (HSC). The hydrogen cost and environmental impact are the main metrics included while the social aspects are rarely involved in the analyses. To cover this gap, this work focuses on the social criteria related to the HSC targeting the identification of the applicable quantitative metrics. A multidisciplinary team has developed the research to include the perspectives from social science, sustainability and engineering. The social aspects applicable to the HSC have been identified through a literature review. The impact on energy security, health and safety risk, social cost-benefit, acceptability, employment (jobs, training) and sustainable supplier practice, are some social indicators that can be included in different frameworks with important implications in the design of resilient HSCs and social wellbeing.

**Keywords:** Sustainability; Hydrogen Supply Chain; Social aspects; Supply Chain Management

# Electric Vehicles and Solar Panels Co-Adoption via Diffusion Models

Sebastian Souyris<sup>1</sup>, Subhonmesh Bose<sup>1</sup>, Sridhar Seshadri<sup>1</sup>,  
Diego Ybarra Arana<sup>2</sup>

*1 University of Illinois Urbana-Champaign, USA*

*2 Universidad Pontificia Comillas, Madrid, Spain*

Electrification has been identified as a critical enabler of the decarbonization of transportation. Therefore, it is imperative to study the adoption growth in solar photovoltaics (PVs) and electric vehicles (EVs) to plan for this impending transformation. However, existing PV and EV adoption studies typically ignore the influence between them and other green technologies, such as the evolution of charging stations. We employ state-of-art techniques in structural economics, the dynamic discrete choice model, to study the diffusion of these technologies. Our work projects the adoption of PV and EV trends into the future under plausible counterfactual scenarios.

# Performance-based Contracts for Energy Efficiency Projects

Ali Shantia<sup>1</sup>, Sam Aflaki<sup>2</sup>, Roman Kapuscinski<sup>3</sup>

*1 Toulouse Business School, Toulouse, France*

*2 HEC Paris, Paris, France*

*3 Ross School of Business, USA*

Energy Service Companies use performance-based contracts for Energy Efficiency projects. The performance of these contracts, however, is unverifiable by the clients. The achieved efficiency also encourages the client to consume more energy (the rebound effect). We show that the mentioned effects, along with the client's risk aversion, diminish the performance of such contracts; therefore, they never achieve the first-best (FB) outcomes. We define and characterize a group of piece-wise linear contracts that perform reasonably well when FB outcome is difficult to achieve.

# Using LSP in Lean Thinking Pedagogy

Ahmed Deif

*California Polytechnic State University, CA, USA*  
*adeif@calpoly.edu*

This work builds on an ongoing research to explore the impact of using gamification to improve student's engagement during teaching Lean concepts and tools. Lego Serious Play method is used to allow students to explore different dimensions of the Waste/Value fundamental concepts by going from 2D to 3D teaching. The employed approach taps into the strong connection between hands and brain to encourage students to demonstrate their understanding of the Waste/Value concepts through building 3D models (or landscapes) of different types of wastes as well as other models for the value expected by their projects' customers.

The designed experiment included a 2D typical lecture to explain Waste/Value concepts, an LSP workshop followed by models building and then finally a pre-designed survey to capture the students experience. Results of data gathered (over two quarters from different students) a clear improvement and clarity among students in their understanding of the targeted Lean concepts, high level of engagement and social interaction and finally a higher readiness level to proceed with their Lean tools implementation in their practical projects.

This work adds to very limited work on researching the impact of Lean gamification especially using the powerful hands-on tool of Lego Serious Play. It further demonstrates how abstract concepts of the Lean paradigm can be better taught to audience with limited to no practical experience in a powerful way that compensate for this important requirement (of practical experience) to appreciate the Lean thinking impact. Finally, various practical recommendations for Lean educators are presented based on this experiment.

**Keywords:** Lean, Gamification, Lego Serious Play